Introduction

Today, semiconductors cannot be manufactured without using machine vision. In fact, machine vision is an enabling technology that has made it possible to achieve the density featured in today’s integrated circuits and permits cost-effective manufacturing of such circuits. Suppliers of electronic materials, active components, IC packages, passive components and finished electronic equipment all use machine vision to drive high quality production at lower costs.

The technology that serves as the basis of both 2-D and 3-D machine vision is becoming more powerful and even more useful in electronic assembly applications. Vision systems now offer even higher resolution, greater speed and better color properties. Lighting is more capable thanks to LED development which is making multi-directional and sequential lighting more cost effective on production lines.

Vision system products featuring powerful vision tools and deployed by professionals with extensive application expertise enable electronics manufacturing engineers to meet tough production and packaging requirements for product quality and safety.

Inspection Challenges in the Electronics Industry

Surface mount devices (SMD) such as transistors, capacitors, resistors and other components shrink in size to just a few millimeters or less allow for greater density and functionality on printed circuit boards (PCBs). The combination of size reduction and increased functionality has greatly improved the performance capabilities of electronic devices but made it practically impossible for either manual assembly or inspection at cost-effective production speeds.

For many years, machine vision has been a critical tool in PCB warpage inspection prior to device population; SMD picking, placement, and mounting verification; and solder validation. Using 2D and 3D solutions, machine vision locates the PCB on the tray, guides high-speed pick-and-place robots to individual SMD components for picking, guides the arm back to the PCB to place the SMD and, finally, validates the solder connections for each SMD lead through the PCB via or mounting hole.

Without the speed and precision of machine vision as a robotic guidance mechanism, assembling modern PCBs would not be possible. In addition, solder validation would be completely impossible using manual methods due to the density of the components on the board. Machine vision not only validates the connection, but also provides feedback on defects in the event of solder cracking, inadequate reflow or other process characteristics that manufacturing engineers need to troubleshoot on problematic assembly lines.

As both passive SMD and active microprocessor components continue to shrink in size, the chance of the wrong component being placed, or reversed on a fast production line can only be determined through an automated inspection routine provided by machine vision technology. As with the SMD device example, machine vision allows electronics manufacturers to correctly place and verify components before additional value-add steps are taken, reducing rework and improving production yields.

Historically, laser scanning devices were used to verify the miniscule solder connections on each SMD and microprocessor lead where it connects to the PCB. While this approach allowed the manufacturer to automatically inspect the increasingly small pitch between devices, laser scanning was slow and expensive. New 3D machine vision techniques allow for volume analysis of solder paste, balls, etc. to validate electrical connections before additional value-add steps are taken.
This has become even more critical in light of new government regulations such as Restriction of Hazardous Substances (RoHS) that prevent the use of toxic metals, such as lead, in electronics components manufacturing. While safer for the environment, replacement solder materials using tin and other metals bring a new set of challenges to the electronics manufacturer, such as whiskers, along with more common problems like gaps and cracks. Each of these conditions requires careful control of the reflow solder process to prevent shorts and bad connections. Only through careful monitoring and use of real time machine vision inspection data can manufacturing engineers hope to maintain control of their solder processes.

**Product Traceability/Supply Chain Management**

To ensure product safety and efficient recalls, producers must be able to quickly identify and locate potentially faulty parts in the supply chain that could pose a hazard to consumers.

While electronic product prices have remained relatively stable in the face of increasing functionality thanks to cost savings from miniaturization and automated assembly, manufacturers must have visibility across their production floor to maintain profit margins. This means product inspections at each manufacturing node and closed loop control of automated assembly processes must be performed successfully before additional labor and energy are expended on defective products.

At the same time, manufacturers face a greater regulatory burden to track their products and validate environmental compliance as well as the need to limit liability from product recalls caused by defective components from secondary suppliers. In each of these cases, machine vision product tracking is at the cutting edge of the enterprise network, tracking all products throughout the manufacturing process and providing management with the data they need to optimize production while protecting their company from financial risks.

---

**Machine Vision Products for Electronic Component Manufacturing**

**VISION SENSORS** are all-in-one solutions featuring a built-in camera, processor, lighting, optics and input/output capable of detecting and inspecting up to 6,000 parts per minute. For electronics manufacturers, vision sensors can check component orientation on the production line. These sensors deliver reliable readings even with variable positions and sizes. They help reduce production downtime and maintain high speeds by eliminating position adjustments and minimizing resets.

**VISION SYSTEMS** are unmatched in their ability to inspect, identify and guide parts. These self-contained, industrial grade vision systems combine a library of advanced vision tools with high-speed image acquisition and processing. A wide range of models, including line scan and color systems, meet all price and performance requirements.

**VISION SOFTWARE** combines the power and adaptability of advanced programming with the simplicity of a graphical programming environment. A library of powerful, proven vision tools allows for total hardware independence, no matter what camera, frame grabbers and other peripherals you use. VisionPro® is ideal for systems integrators, OEMs and advanced vision users that require large numbers of cameras or applications that integrate with existing PC and human machine interface (HMI) hardware.
Cognex Tools Helping Improve Quality for the Electronics Industry

**INSPECT**
Machine vision inspects for assembly errors, surface defects, damaged parts and missing features. Vision tools identify the orientation, shape and position of objects and features.

**GUIDE**
Vision software guides automation equipment and robotic devices. Proven vision tools align parts for high accuracy assembly operations and other manufacturing processes.

**GAUGE/MEASURE**
Vision tools gauge parts to check critical dimensions and measure product components for sorting and classification processes.

**OCR/OCV**
Powerful algorithms read and verify alphanumeric characters marked directly on parts and printed on labels.

**PRESENCE/ABSENCE**
Cognex vision devices detect the presence or absence of simple features and objects on high-speed production lines to give basic pass/fail results.

**CODE READING**
Specialized tools read 1-D barcodes or 2-D matrix codes from slow moving to high speed and hard to read direct part marked codes.

---

Machine Vision in Action in Electronics Manufacturing

**VisionPro helps shorten application development time and reduce lifecycle costs**

**Company:**
ASYS Automatisierungssysteme GmbH, Dornstadt, Germany

**Challenge:** Complete component traceability in its prize-winning INSIGNUM 2000 laser marking system.

**Machine Vision Product Deployed:** VisionPro Software

**Solution:** Digital data printed directly on products allows for complete component traceability even in high-volume production environments and the use of laser marking technology guarantees extremely low error rates in this process. The performance and flexibility of the hardware installed to facilitate this process is entirely dependent on the quality and functionality of the image processing software being used.

**Benefits Achieved:** Cognex VisionPro vision software is fast, accurate and powerful. With VisionPro integrated the INSIGNUM 2000 was awarded the NPI Award. The INSIGNUM 2000 Laser now reads up to 20 codes in less than 15 seconds, including handling.

---

In-Sight provides fast inspection of overheated temperature controllers

**Company:** Bangze Equipment, China

**Challenge:** Perform inspections of heat protection short circuits in temperatures of around 300°C (572°F), and at short circuit distances of only around 1mm (0.04 in).

**Machine Vision Product Deployed:** In-Sight® vision systems

**Solution:** A vision system was installed in a very narrow insulated space and using the edge tool found in In-Sight Explorer software, the bi-metal sheet edges are found. Finally a measurement tool is used to measure the direct distance between the two lines.

**Benefits Achieved:** After the system receives the inspection signal, the In-Sight system makes ten heat protection measurements at a precision of ±0.04mm and send a signal within 10 milliseconds, providing Bangze Equipment with ideal production manufacturing conditions.
**In-Sight provides optical control of lasered codes on PCBs**

**Company:** Rommel GmbH, Ehingen, Germany

**Challenge:** Use lasered Data Matrix codes to ensure that the PCB boards are produced without errors.

**Machine Vision Product Deployed:** In-Sight vision system

**Solution:** Rommel GmbH uses an innovative laser scan head that features a moving deflection mirror, CO<sub>2</sub> lasers and the In-Sight vision system to reach its precision goals.

**Benefits Achieved:** The intelligent and complete In-Sight vision system helped Rommel execute the required laser marking tasks perfectly. Captured images and data are easily handled using In-Sight Explorer software and the extensive library of proven vision tools. In addition, the system’s robust diecast aluminum and stainless steel housing are highly effective in making the intelligent vision system resistant to high vibration stress and protecting the inner workings of the system against dust and debris.

---

**Easy to use vision system helps connector manufacturer achieve zero defects**

**Company:** JST, USA

**Challenge:** Implement a vision system that measures parts to an accuracy of 0.1 mm in order to adjust machine parameters quickly enough to avoid defects.

**Machine Vision Product Deployed:** In-Sight vision system

**Solution:** An In-Sight vision system provided a complete solution in a modular package and did not require any additional hardware or other equipment. The high resolution, fast image acquisition time and easy to use vision tools made it a perfect choice.

**Benefits Achieved:** The number of nonconformances in the period immediately following machine vision deployment was reduced to 0 parts per million (ppm), well below the extremely tough six-sigma quality benchmark of 3.4 ppm.

---

**High precision inspection over a large surface area**

**Company:** Meder, Shanghai, China

**Challenge:** Inspect printed circuit boards (PCBs) with a high degree of precision.

**Machine Vision Product Deployed:** In-Sight vision system

**Solution:** A mechanical movement strategy created an XY-direction two-dimensional platform and included an In-Sight vision system along with three grouped light sources to perform the inspections.

**Benefits Achieved:** The method used guaranteed high precision and ensured that large areas of the PCBs can be inspected. This is a significant technical advance for the machine vision industry.
Supply chain management made easy with machine vision

The better and more precise the traceability system in an electronics manufacturing process, the faster problems can be identified and resolved. Here are four ways machine vision helps manage the supply chain:

1. Improves management of work in process
2. Reduces inventory
3. Optimizes availability and use of production tools
4. Minimizes distribution of non-conforming products

Summary

With capacitors and other passive components measured in the microns and critical dimensions of semiconductors measured in nanometers, automated machine vision offers the only cost-effective way to check the quality of semiconductor components and electronic assemblies. When combined with direct automated signal testing, machine vision puts manufacturers in control of each step in the electronic manufacturing process—from incoming component inspection, to assembly, packaging and shipping.

Furthermore, machine vision’s ability to read 2D data codes on components and JEDEC tray symbols give OEMs the capability to view and manage their entire supply chain, resulting in lean, profit-driven electronic enterprises for today’s fast-moving markets.